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TECHNICAL NOTE

Endeavours in seismic monitoring of oceans through drifting network with development of a New Generation Mobile Earthquake Recorder in Marine Areas by Independent Divers---The Son-O-MERMAID

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INTRODUCTION

Our understanding of the internal dynamics of the Earth is to a significant extent based on images of seismic velocity variations in the earth's mantle obtained through global seismic tomography (Sukhovich et al., 2015). While the land is covered by a dense network of seismic stations, the coverage in the Oceans is inadequate mainly due to the high cost of installation and recovery of the conventionally used sensors such as Ocean Bottom Seismometers (OBS) and moored hydrophones. This unequal seismic data coverage fundamentally limits the quality of tomographic representations of seismic wave speeds in the earth's interior (F.J Simons et al., EOS v.87, no.31 1st Aug 2006). To overcome this problem some important measures have been taken in the recent past. Some specifics are given below to highlight the efficacy of such techniques and recording instruments.

NEW INITIATIVES

A) Requirement of floating seismic stations or MERMAID (Mobile Earthquake Recorder in Marine Areas by Independent Divers)

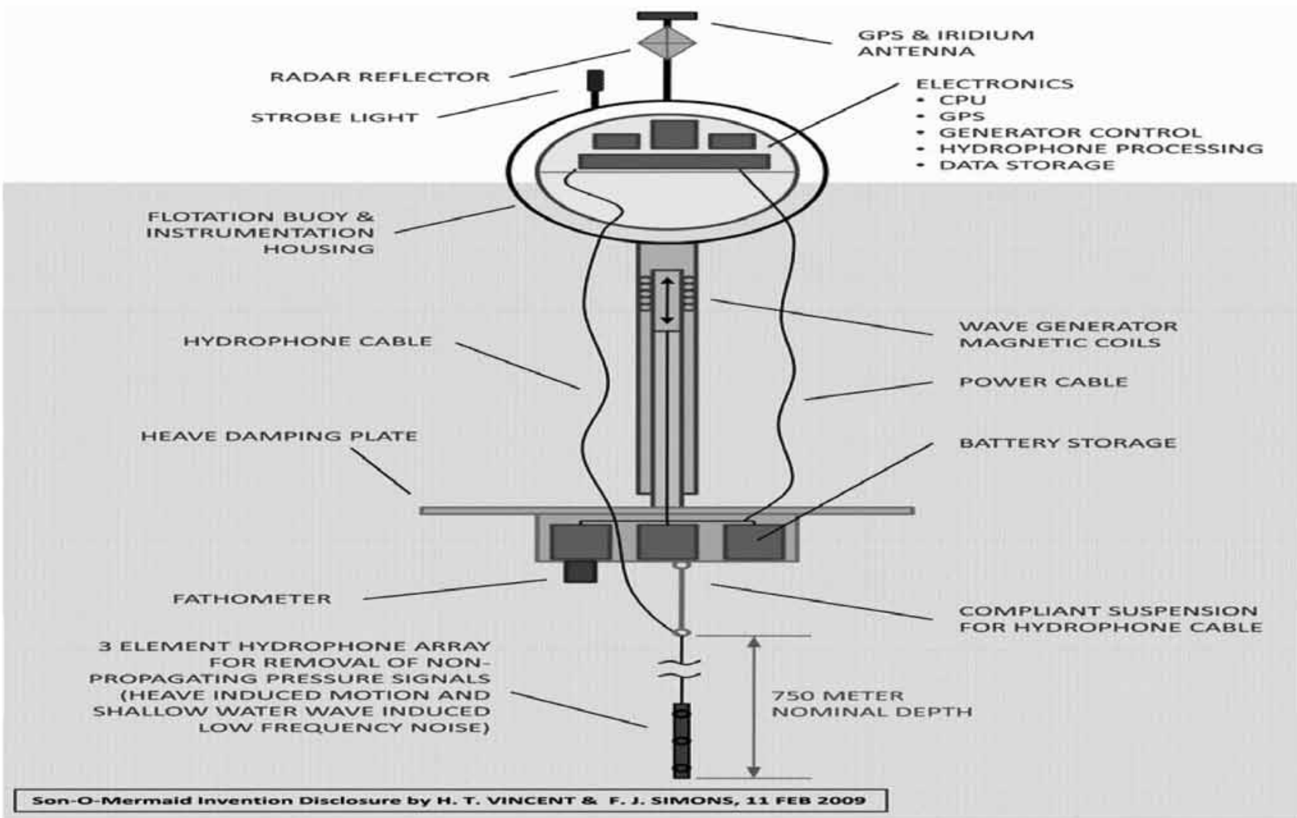
A remedial solution includes apt observation of seismic waves in the oceans to obtain adequate data coverage in oceans using a prototype of a mobile receiver that will function as a floating seismometer (developed by Prof Dr. Guust Nolet of Geoazur in France). This prototype was nicknames "MERMAID", which stands for Mobile Earthquake Recorder in Marine Areas by Independent Divers. The Mermaid is an autonomous freely drifting underwater robot, which by changing its buoyancy can dive up to and remain at a programmed depth. A seismic wave (i.e. P wave) arriving at the ocean bottom refracts into the water and generates acoustic wave, which propagates vertically. Whenever an acoustic wave generated by teleseismic P wave is detected by the MERMAID, it moves up to the ocean surface as quick as possible to transmit via satellite the recorded signal and information such as time of arrival of the signal, depth of the robot at the moment of detection etc. The principal advantage of the MERMAID over Ocean Bottom Seismometer and Moored Hydrophones is its lower operational costs. The Mermaid was first tested on 4-6 Nov 2003.

B) Development of Son-O-Mermaid--the New Generation Mobile Earthquake Recorder in Marine Areas by Independent Divers

The Son-O-MERMAID instrument is a next generation drifting prototype, jointly developed at the University of Rhode Island (URI) by Prof. Harold Vincent and at Princeton University by Prof. Frederik Simons. It combines a surface buoy with instruments dangling from an un-tethered cable. Son-O-Mermaid was initially deployed at off the coast of Bahamas on October 9th, 2012.

B-1) System Description and working of Son-O-Mermaid

Son-O-Mermaid operates at a water depth of about 1500 meters, while a drifting buoy stays at the surface and allows the continuous contact with a satellite. The surface unit enables the GPS and IRIDIUM capabilities to be always engaged. Son-O-MERMAID can be divided in to three subcomponents: **First**, a surface component that receives and stores the acoustic data sent from the submerged unit for further analysis. This unit is accurately time synchronized with a GPS receiver and used to time stamp the acoustic data. **Second,** a submerged component immersed at a depth of ~750 meters. It collects, digitizes and samples acoustic data. The submerged component includes the following parts: (I) a three-hydrophone array, spaced about 70 cm apart at the end of a 750 m long cable attached to a surface buoy that houses electronics, communications, and a GPS location package(ii)an analog to digital converter (ADC), (iii) a central processing unit (CPU) and one RS-485 adapter. All these parts with the exception of the hydrophones are placed inside a pressure vessel. **Third** is the interface that connects the submerged and surface components.



Son-O-Mermaid: Picture Courtesy: Princeton University
(http://geoweb.princeton.edu/people/simons/MERMAID.html).

B-2) Technical Advancement of Son-O-Mermaid over its predecessors and advantages over OBS (Ocean Bottom Seismometers)

Son-O-Mermaid is a freely drifting buoy that (a) derives energy from wave action, enough to power (b) a vertical array of hydrophones suspended from a compliant cable connected to a damping plate below the waves, (c) a full-ocean-depth echo sounder, (d) GPS for location and timing accuracy, (e) an IRIDIUM satellite communication unit for near real-time data transfer, and an (f) on-board digitizing and processing unit. The predecessor instrument, MERMAID, does not have facilities mentioned under (a), (c) and array aspect of (b). The Son-O-Mermaid can be deployed even by untrained personnel. This gives it an extra advantage over conventional approaches e.g., ocean-bottom seismometers, tethered, moored hydrophones. Unlike traditional ocean-bottom seismometers, which are placed in stationary locations and must be retrieved to obtain their data, Son-O-Mermaid drifts with ocean currents and regularly reports data back to scientists using wireless technology. Several of these recorders can be deployed for the same cost as one ocean-bottom seismometer. Compared to its progenitor MERMAID, the new float (Son-O-Mermaid) has better real-time communication capabilities because part of the instrument is always above water, and, in addition to batteries, has solar panels that power a vertical array of hydrophones. Energy harvesting technology will give Son-O-Mermaid great operational independence and the possibility to take payload for ocean-based observations not limited to hydroacoustics for seismic tomography. The hydrophone array configuration eliminates non-propagating noise and suppresses surface multiples. The fathometer helps in determining the travel time of teleseismic waves with maximum accuracy. It will also deliver data for the high-resolution study of Earth's global bathymetry. As Son-O-Mermaid is a drifting instrument it helps to generate data on sea surface currents. (https://www.nsf.gov/awardsearch/showAward?AWD_ID=1318416).

B-3) LIMITATIONS

Son-O-Mermaid does have drawbacks. Since the buoy is at the surface, in the waves, it can get run over by ships — or be hit by a hurricane.

FUTURE STRATEGIES

a. Keeping in view the tremendous capability of the Son-O-Mermaid to detect teleseismic waves in the ocean, and transmit the information to land centres in near realtime, there is a need for deployment of a large array of Son-O-Mermaids mainly in the southern Oceans (For ex Indian Ocean), which are not adequately covered by seismic sensors. Such a deployment helps to provide a denser tomographic data; a useful input for better imaging of deeper structures.
b. There should be networking between various sensors (Son-O-Mermaids, Ocean Bottom Seismometers, Tsunami Bouys, Moored hydrophones), as exchange of data ultimately results in better scanning of structures present at shallower to deeper depths.
c. Moreover, in the near future the Son-O-Mermaid will be fitted with multiple instruments like meteorological and oceanographic becoming multipurpose and multidisciplinary platforms for all types of scientific research in the oceans. (Simon J.D et al AGU 2014, Nolet G et al; AGU Dec 2014, Dec 2017 issue of IASPEI News letter) ultimately paving the future vision for a large array of drifting Geophysical observatories (Multidisciplinary Mermaids)in the ocean.(Hello Y et al; AGU Dec 2013), (Nolet G et al; AGU Dec 2014)

CONCLUSION

The Son-O-Mermaid will help to revolutionize seismic data collection in the oceans, by better detection of signals and near real time transmission of collected data. The Son-O-Mermaid will help to revolutionize seismic data collection in the oceans, by better detection of signals and near real time transmission of collected data. (Simon J.D et al AGU 2014), (Frederik J. Simons et al; Journal of Geophysical Research 23rd May 2009).

ACKNOWLEDGEMENTS

This technical Note has been compiled using internet information and other sources, basically to propagate the importance of Son-O-Mermaid the new generation drifting seismic tool. I unequivocally state that the technical details given above have not been developed by me either directly or indirectly. I thank Dr.P.R.Reddy for apt editing and recommending its publication as a Technical Note. The views expressed in the article are solely the views of myself and not of my organisation.

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Picture Courtesy: Princeton University (http://geoweb.princeton.edu/people/simons/MERMAID.html)

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